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A
T R E A T I S E
O N
E L E C T R I C I T Y :

W H E R E I N

Its various *phænomena* are accounted for, and the cause of the *attraction* and *gravitation* of solids, assigned.

TO WHICH IS ADDED,

A short account, how the electrical *effluvia* act upon the animal frame, and in what disorders the same may probably be applied with success, and in what not.

By FRANCIS PENROSE
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They who are universally allowed the very greatest, and wisest of men, have been, and still are, intent upon the making of *observations*, and *experiments*: and surely that must be in order to some further end. These would be vain, and wholly useless, were not some reflections made, some conclusions drawn, some theory or hypothesis raised from them.

Woodward's state of physick and of diseases, p. 55.

O X F O R D,

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O N

E L E C T R I C I T Y.

THE many surprising effects of *electricity*, and the great cures performed by it, one would imagine, should awaken the attention of all philosophers and physicians; but as these cures have been effected by random experiments, every body has admired, but no body seems to have considered how, or by what means, they were performed. Whence

Notwithstanding all these surprising *phænomena*, from which many have entertained hopes of a great addition to the healing art; yet not one tolerable account has been given, how, or from what cause, these *phænomena* proceeded; except what has been done by Mr. *Freke*, surgeon to *Bartholomew hospital*; whose admirable piece shews the great penetration of its worthy author, with whom I shall join in thinking “it may possibly be the beginning of much good.”

One

One would think, this silence, on so interesting a subject, *in this enlightened age*, can proceed from nothing but a prejudice in favour of wrong principles of philosophy : That this is certainly the taste of the present age, M. *Freke* seems very well convinced ; for, at the end of his pamphlet, he takes notice of a show-man, who, “ having
 “ published some experiments in electricity, and
 “ hearing that Mr. *Freke*’s piece was publishing,
 “ own’d, he was much affrightened, because of
 “ the hard fate, as he said, of his booksellers ;
 “ but, before he had read two pages, he likewise
 “ owned he had recovered his spirits, when he
 “ found Mr. *Freke* pretended to think for him-
 “ self, and did not let Sr. *Isaac Newton* think for
 “ him.”

Now, if all persons would take the same freedom of thinking for themselves, as Mr. *Freke* has done, I doubt not but we should soon be as much ashamed of mentioning the *attraction of gravitation*, and the *attraction of cohesion* &c. as we now are of the *occult qualities* of the ancient philosophers ; and should perhaps, then agree with him, when, speaking of electricity, he says, that “ it is a subject which can, with
 “ more nobleness and dignity, employ the mind
 “ of man, than any he can think of, relating to
 “ the sublunary part of the world. For by it
 “ you

“you may be acquainted with the immediate
 “officer of God Almighty, which he seems to
 “send to all things living: Nay, this power, (ac-
 “cording to his conception,) seems to be the
 “cause, under HIM, both of life and death.
 “And when it may be more fully understood, it
 “may afford us means, whereby we may be bet-
 “ter enabled to reason more intelligibly, than
 “now we can, concerning various operations in
 “nature.” Therefore,

In the following essay, I shall endeavour to
 shew,

I. How, and from whence, this electrical fire
 and force are produced; in doing of which I
 shall make some observations, in order to shew
 that we may form a more exact idea of most of
 the great operations of that complete machine,
 the universe, from electrical experiments, than
 can be attained by any other means: I shall also
 produce some experiments which demonstrate,
 that the terraqueous globe has no *attraction*; nor
 a solid body, falling towards the earth, any *gra-
 vitation*; after which, I shall bring other expe-
 riments to prove what is the cause of *solidity*, and
 by what means bodies *gravitate* towards the
 earth.

II. How

II. How this electrical fire and force act upon the animal frame, and in what disorders they are likely to be of benefit, and in what not.

I. We are certain, that this electrical fire is produced, either from the glass globe, or the air that surrounds it. As to the glass globe, Mr. *Freke* has fully proved it cannot proceed from that; "Because nothing, we know of, can send
"out of it a quantity of matter, but there must
"be less of that matter remaining, after it has
"been so discharged; whereas it cannot be
"shewn, but that the glass globe, after ever so
"many times using, remains as fit for the same
"use, as at first." From hence we assert, that this fire must proceed from the surrounding air being acted upon by the glass globe; and our inquiry must be, how, and by what means, fire is produced by the glass globe being made to act upon the air; by which inquiry we shall find, that *air*, *light*, and *fire* are of the *same substance*, or *essence*; only differently modified, and appointed for performing different actions: that air (by being divided or broke to pieces) produces light; and, if that action is still encreased, it produces fire. Now as the greatest friction or attrition are necessary to produce fire, so fire, when it is once produced, having received the greatest force, of consequence *acts* with the greatest force;
and

and light, with a less; so, wherever there is the greatest quantity of these small particles of air, (which we call by the name of fire) in proportion to what we call gross air, there the action must be the greatest; by which means the said fire or light will expand itself, 'till, by mixing with what we call gross air, it becomes of an uniformity with it. Now therefore, as experiments are the sure way either of proving or disproving any *hypothesis*; so, to illustrate this, I shall produce some experiments both from Mr. *Freke*, and other authors of unblemished credit, which prove that air is convertible into light and fire, and also that light and fire are convertible back again into air; and likewise, as some parts of the air are present in all places and things, that therefore, whenever a violent action either of solids or fluids is brought on, there light, fire, or heat, are produced.

To prove this, Mr. *Freke* has brought, two very simple, common, but good experiments --- First, if you slide a wax thread, or small rope, through your fingers, it will burn them; so likewise fire is produced, by rubbing two hard bodies together, or two sticks; or, as is very often the case, a cart or coach wheel will take fire, for want of grease.

Ano-

Another no small proof of this, is what Mr. *Freke* has mentioned, viz. that in the year 1703, in the night of the great hurricane and high wind, in the strongest part of the tempest, great quantities of fire were seen passing swiftly over the hills in the neighbourhood of *Warham* in *Dorsetshire*. The cause of which fire seems very easily accounted for, according to the above theory, which might otherwise perhaps, elude the searches of our greatest philosophers: for in this phenomenon it is plain, that the attrition of the particles of the air was so great by the motion of the wind, as to produce fire or light. Mr. *Freke* has some other observations, which much strengthen the above theory, viz. that in tempestuous weather, at sea, great flakes of fire are frequently seen passing, not only in the air, but on the water. The like is also observed, in the night time, when the surface of the water is disturbed with the feathering of oars, or by a vessel or boat passing swiftly through it. This light or fire *in storms* is no new observation; for Mr. *Boyle* says, it is common in storms for the fire called *Helena*, *Castor*, and *Pollux*, to hover about the masts of ships. And, indeed,

To shew that fire or heat are produced in any place, or thing, where there is a sufficient motion, seems not to be very difficult; for water is the

the opposite to fire ; and yet, by mixing water and spirit of wine *suddenly* together, a heat ensues ; and this will happen if they have been separated ever so often ; but this heat vanishes again after they are mixed, or as soon as the *motion* of their parts ceases. The like will happen by mixing salt of tartar and water. This phenomenon seems to proceed from the disposition and texture of the salt ; whose pores are made of such a proper size, that, on receiving the water by the pressure of the atmosphere into them, the texture of the salt may be thereby broken, and its parts put *into motion* ; which *motion* causes an *attrition* of the air, and so produces a sensible heat.

Boerhaave has another observation, which seems to prove to a demonstration, that fire or heat is caused by an *attrition* of the air ; which observation I shall give in his own words. “ A
 “ cannon ball, shot in the winter time, will fly
 “ 600 feet in a minute through the cold air,
 “ which makes a greater resistance than any
 “ wind, the most rapid of which only moves
 “ $22 \frac{1}{2}$ feet ; hence it appears how much *friction*
 “ the ball must have undergone in its passage,
 “ which by the way did not proceed in a right
 “ line, but by its whirling motion continually
 “ describes a cycloid with every point of its body.

B

“ When

“ When it falls, it is found quite hot ; notwith-
 “ standing in its whole passage, it had continu-
 “ ally met with cold air. This heat could not
 “ have arisen from the flaming gunpowder,
 “ whereby it was exploded, since it only remain-
 “ ed in that flame, an incredible small space of
 “ time, in which it is by no means credible so
 “ solid a body should have acquired such a heat;
 “ which is much more naturally accounted for
 “ from the great attrition of the ball, driven with
 “ such a velocity through the air, and repelled by
 “ a wind, which is above 27 times swifter than
 “ the strongest wind hitherto observed.” *Boer-*
haave's Chym. by Shaw, Vol. 1. pag. 244.

I shall mention one more experiment from
Mr. Boyle, which proves that *air* is not only con-
 vertible into *light* ; but that it may afterwards be
 forced through glass, and thereby the same *va-*
cuum be made that is by an air pump. “ Liquid
 “ phosphorus being put into a vial, when it was
 “ disposed to shine in the dark, the cavity of the
 “ vial above the liquor seemed to be full of whi-
 “ tish fumes, though at other times transparent.
 “ The vial, when close stopped, was not lumi-
 “ nous in the dark, but the light or flame ap-
 “ peared as soon as it was exposed to the air, and
 “ the vial was unstopped ; and that the occasion
 “ and propagation of this flame depended on the
 “ con-

“contact of the air, appeared, since agitation
 “would not kindle it, but when the bottle was
 “unstopped, the kindled flame would gradually
 “be propagated downwards; the flame always
 “appeared most vivid the nearer the air, and
 “when it was extinguished, it first disappeared
 “in the bottom, and then expired at the top.
 “When the Vial was unstopped for some time,
 “when it was stopped again, the air that had lei-
 “surely insinuated itself would cherish the flame
 “for an hour or two. It was observable, that
 “when the air had been long pent up with this
 “shining liquor, its resistance would be so weak-
 “ened, that when the vial was unstopped, the
 “external air would presently rush in with vio-
 “lence, from whence appears the interest of the
 “air in propagating the shining of this liquor.
 “The agitation before the vial was unstopped
 “would not kindle the light; yet when it was
 “opened, it would be increased by it, and even
 “when it was in its dull state, if I poured a lit-
 “tle of it upon my hand, and rubbed it with
 “my finger, it would presently become vivid,
 “and emit store of luminous rays, as well as
 “fumes very offensive to the nostrils; and when
 “I ceased to rub, and the luminous quality was
 “lost, it would be renewed again by a repeated
 “attrition; but in a little time its lucid virtue
 “would

“would decay.” *Boulton's Epitome of Boyle's works*, vol. 2. pag. 246. From these experiments it may be observed, that this liquid phosphorus could not be made to emit light, without a communication with the air, not even by the utmost agitation ; though when it had a free communication with the air, a small agitation greatly increased the quantity and strength of the light ; that, whenever the air was admitted to join it, a violent intestine motion came on, by which motion or attrition, light was not only produced, but also a great deal of the liquid was carried off by it ; which might be perceived either by the sight, or smell. And when the vial had been long without a cork, by which means it was filled to the utmost with air, the light would continue a considerable time after the vial was stopped. We likewise find, that, after the vial has been stopped some time, and the liquor has acted upon the air as much as it possibly can, there is not only a less quantity of gross air than there was when the vial was first stopped, but that there is the same *vacuum* as is made by the air pump ; for as soon as ever it is unstopped, the air presseth in with violence, the fluid above the phosphorus (within the vial) being of a more subtle nature than the air without.

This

This experiment seems sufficiently to prove, that air and light are of the same essence or substance; for we are certain that gross air entered the vial, and, when it was first stopped, the quantity of gross air was of an uniformity with the air without the vial; but at its being opened, we are assured, there was a less quantity than when it was first stopped; for the air without presseth in with the same violence it does into the exhausted receiver of an air-pump; by which we may be assured, that some parts of the air have passed the vial in form of *light*; and, as the pores of the glass are not big enough to admit gross air to return, the consequence must be, that there is a less quantity of gross air in the vial at the opening, than there was, when it was first stopped.

Fire and light are easily proved to be dispersed through the whole air, from the immediate action of *speculums*; and that air itself is of the same substance with fire seems very plain; for as fire cannot subsist without air, (and in proportion to the quantity of air forced into the fire, in such proportion will be the force of the fire;) so, neither can fire act but on the outside of bodies next the air; for even the most inflammable bodies can only catch fire on their outermost surface contiguous to the air; and fire in
action,

action, if immersed in a body of the most inflammable matter, so as to leave no lighted part above such surface in the air, will be so far from kindling the inflammable body, that itself will be extinguished. Thus “if a flaming brimstone
 “match be plunged into the highest rectified spirit of wine, the spirit of wine will extinguish
 “it as intirely, as if dipped in cold water ; it
 “will also extinguish a live burning sparkling
 “coal ; but in the former experiment, if the least
 “bit of the burning match remains above the
 “spirit of wine, it will then catch fire, and the
 “flame will presently spread over the whole surface.” This is an experiment of the great *Boerhaave*, in the first vol. of his chymistry, by *Shaw*, pag. 316.

All these experiments, I think, prove to a certainty, that air is convertible into light. I shall now bring one experiment, from *Boerhaave*, Vol. 1. p. 998. which proves, that fire or light may be changed into air.

“If a spherical glass vial be kept in a glass-house furnace, till ready to melt, and then be
 “hermetically sealed in that heat, and suffered
 “to cool ; if now, it be held inverted, under
 “cold water, and the end of the neck be carefully broken off, the water will be violently
 “forced into it, and fill the glass, but so as to
 “leave

“leave a bubble of true elastic air at the bottom.”

The above experiments prove, that, whenever air is sufficiently divided or broken to pieces, light is produced; so that the light or heat in electricity, is no other than, we find, may be produced several other ways. For the air being violently rubbed or ground to pieces between your hand and the glass globe, whirled briskly about, the air between your hand and the globe is ground so small as to be in the form of *light*, which is expanded or sent off from the glass globe in the same manner as *light* from a candle, or other luminous body; which emission is continually supplied by the common air pressing in between the rays of *light*, emitted from the glass ball. That this is the method, by which it acts, seems very clear: for you may not only hear the hissing noise of the air pressing towards the globe, but also plainly feel the air with your hand, near the globe or tube.

The chief reason (and what has been our great misfortune) that we have not been able to discover the cause of electricity, seems to be the leaving that philosophy, which has been *revealed* to us, and putting in its stead *theories* of our own *invention*. For, if we had considered (from the *revealed* account that is given us of the formation
of

light) the *method* of its *first* production, we should not be at such a loss to account for that light in electricity, as we hitherto seem to have been; for we are *there* told, that the *heavens*, or airs, were created in a state of *darkness*, or inactivity; and that the first thing God did, was to cause a *motion*, or *wind* amongst the airs; which *motion* was to *continue*, and *encrease*, till it produced *light*; and, after this *light* was produced, God called it *Day*, or as it is expressed in the original, *tumultuousness*; it being produced from the impetuous or violent motion of the airs: and the *darkness* he called *night*, or, as it is likewise expressed, the time when this *languishes* or *decays*; for the *congealing* or *thickning* of the air, by which *darkness* is produced, is in proportion as the *force* of the *light* abates.

By all which, I think, we may be assured, that the *light*, and all the *phænomena* produced in electricity, are caused by a violent *friction* or *grinding* of the grains of air between the glass globe and the hand.

To illustrate and prove, that this is the method by which the electrical *light* is produced, I shall bring some experiments, from Mr. *Hauksbee*, which, I imagine, will make it indisputable. In his first and second experiments, he shews us, that by dropping mercury on a glass in an exhausted

hausted receiver, the *action* of the mercury on that subtil fluid gives the mercury the appearance of fire; but observes, that in all these experiments on mercury, no *light* is to be obtained without *motion*, and that the same motion which produced this light in *vacuo*, did not produce it, when given to mercurial globules in *open air*. This experiment shews us, that there was a larger quantity of *light* in the exhausted receiver than when it was filled with common air; nay farther, that the *subtil fluid* contained in the exhausted receiver, was *light*; but, for want of *motion*, was not perceptible by our senses; but by so small a motion as that of the descending mercury, it was pushed forward in the same manner, as *light* from a candle, or other luminous bodies. We also find, that the same experiments performed in an *unexhausted* receiver, would not produce the *phænomenon* of *light*; which one might easily suppose to be the case. For in the *exhausted* receiver, any the least *motion*, that is sufficient to *push* this subtil fluid (*light*) from one place to another must give us the perception of *light*; but in the *unexhausted* receiver the *motion* or *friction* must be great enough, not only to *push* the air from place to place, but also to *break* it so small, as to be in form of *light*: which he shews us by his third, fourth, and fifth experi-

ments to be the case ; for by these experiments he produced *light* in an *unexhausted* receiver ; but then the *motion* or *agitation* was required to be much *greater* than that which produced *light* in *vacuo*. The difference of these two *lights* was *very considerable*, and consisted particularly in this, that the luminous particles are *distinct* and *separate* in the experiment performed in the *open air* ; and *united* and *blended* into one continued body of *light*, in the other experiments in *vacuo* ; which difference proves to a demonstration, that the exhausted receiver was full of nothing but *light* ; for, on shaking the mercury therein, the whole body of the receiver seemed to be *one continued body* of *light* ; but on shaking the mercury with ever so great a violence in the common air, it seemed full only of *little, bright, twinkling sparks* ; and not one continued body, as in *vacuo*. For, as the appearance of *light* is produced in the common air, by the *friction* of the mercury against the glass receiver, *breaking* or *grinding* the air to pieces (which small particles put on the form of *light*) so, when the common air *presses* in between these small particles, the appearance must be, and cannot be otherwise than is shewn by these experiments.

These

These many and various experiments abundantly prove, that *light* is produced as above described; and not, as the generality of people have imagined (from that mistaken notion of *action* being performed by *solids* and not by *fluids*) that this electrical *light* proceeded from the glass globe, emitting, what they call, *electrical effluvia*, which has been shewn before to be impossible; because if any quantity of matter sends off part of its own body, there must be less of that body remaining, than before the above matter was sent off, which we find is not the case of the glass globe; and to prove that it does not, I shall bring one experiment more from Mr. *Hauksbee* which will put it beyond doubt.

Pag. 27. he shews us, that by a violent *attrition* of *woollen* against *woollen* in *vacuo*, he produced *light*, as well as from any *hard* or *electrical* body; but not so vivid, nor in so large a quantity. Now, as *woollen* is reckoned by all to be a *non-electrical* body, it shews us that the *light* must proceed from the *attrition* of the air, and not from the *electrical body*, as has been falsely imagined.

As *light* may be produced by other methods than have been yet described, as from *rotten wood*, *fish*, *meat* &c. I shall endeavour to give an account, how, and in what manner, that *light* is pro-

produced. Mr. Boyle (in vol. 2. p. 233. of the epitome by Boulton) tells us, that by putting *rotten wood, fish, flesh &c.* in the receiver of an air-pump, and then extracting the gross air, they all, in a little time, lost their *shining* or *luminous* quality; but, upon a re-admission of air, this *luminous* quality returned. From which we may learn, that the air is essentially necessary to continue this *light*; and, of consequence, that this *light* is produced by the *action* and *re-action* of the air on the body, which cause an *intestine motion* of its parts; and thereby the emission of the said light; for when any thing begins to ferment and *putrify* (which cannot be performed in any place, but where the gross air is present) the *intestine motion* of its parts is thereby *increased*; which *motion* acting upon the air pressed into it, the air is thereby *ground* very small, and by the continual pressure of the atmosphere is sent out so small, as to be in form of *light*. --- In the common *fermentation* of liquids, when it rises to any height, those particles of *light* being *stopped*, and *entangled* by the *watry parts* of the fermenting mass, thereby produce *heat*; and some mixtures will produce *light, heat* and *flame* on fermentation; as *steel, water, and sulphur*.

By

By these experiments we have a clear idea of the means and method by which *fermentation* is performed, which operation has been hitherto unintelligible. From hence we may likewise see the reason why, in an air either *too hot* or *too cold*, *fermentation* cannot be performed; for in an air *too cold*, the pressure is *too great*, and also the grains of air *too large* to enter and divide the thing to be *fermented*; by which means the *motion* of its parts requisite to *fermentation* is prevented; but in air that is *too hot*, there must be just the contrary effect, for there the parts of the thing to be *fermented* are so far *expanded*, and the air so *rarified*, as to pass through the body with little or no obstruction, and of consequence to produce little or no *intestine motion* of its parts; and that there is in *fermentations* an *intestine motion* of the parts of a *fermenting* liquid, is easily discernible by the naked eye. This also gives us the reason, why the *glow-worm* shines only in the summer months, when the air is greatly *rarified*, or *divided*, and then requires but a small *motion* to give it the form of *light*.

The *light* proceeding from *diamonds* &c. seems to be easily accounted for from the *motion* of the *airs*; that there is a *perpetual motion* of the *airs*, may be proved by the following experiment. In a still place, suppose a close darkened room,

room, illuminated only by one small hole in the window shutter; where, if a person at rest views the enlightened current of air sideways, as it extends along the room, he will perceive a *surprising motion* of the dusty atoms therein, *perpetually rolling and tossing* about with great rapidity. This *motion* must be very *considerable*, as it is *perpetual*, and pushed on with the power of *gravity* in the air equal to a column of water 33 feet high. By this *action* on *diamonds*, whose *pores* are very *small*, and the bodies themselves of such a *make* and *hardness*, as that, when the air is pressed on them with so great a *force* as that of the *incumbent atmosphere*, the air is *broke exceedingly small*, and, by the continuance of the *pressure*, is sent off from the body in form of *light*. We likewise find from experiments, that where *diamonds*, or other bodies of that kind, have not their outward parts of a proper *make*, or their *substance* of a *sufficient hardness* or *closeness of parts*, to emit *light* with no greater *force*, than the *pressure* of the *atmosphere* only, then this deficiency may be supplied by *rubbing*; by which means the air is *ground* to pieces, and emitted in form of *light*, as is shewn in all electrical experiments.

One great property of *light*, or, as it is commonly called the *electrical effluvia*, is (as Mr. *Hauksbee* has proved from many experiments,) that it passes *through glass*, as water does through a sieve, or as if no body of matter interposed. This *light* of itself, when *pure*, or *simple*, hurts or destroys no material bodies; but when *pushed* on by the following air with *great violence*, and *meeting* with a *great resistance* from an impeding body, the *conflict* is so great, that if the following air *presses* on with *sufficient violence*, it *dissolves* or *destroys* the *solidity* of any material body. As all bodies become *solid* according to the *temperature* of the surrounding air; some retaining their *solidity* in such a degree of *heat*, as *metals* of most kinds; whilst others require a particular degree of *cold* before they become *solid*, as *water &c.* which when froze is as much a *solid* as any thing else --- this proves that the *solidity* of bodies depends on the *temperature* of the air, as will be more fully proved hereafter.

The glass globe, with the electrical experiments, seems to give a very clear idea in what manner the *sun* is *supported*, how this *terraqeous globe* and the rest of the *planets* are made to *move*, and *continued in motion*; and also, what is the cause of the *attraction* of the *sun*, *earth*, *moon* and the rest of the *planets*.

That

That the *sun* is the chief, material, ruling agent, is very clearly revealed; as are some of its chiefest actions on the planets and the rest of the universe. For, in the sun we find a power of melting, dividing and (with the assistance of the air) expanding and sending out the air, first in form of *fire*, and afterwards in that of *light*; which power seems to be so regulated, as to be able to reach the extremities of the universe, where it is *congealed*, *condensed*, and *returned* back again to the *sun*, to be again *melted*, *divided*, and sent out as before. This action seems to be represented by water in a *still*, for there the fire, forcing its way through the water contained in the *still*, carries off some of the watry particles with it; and when it has reached the head of the *still*, if it has no passage into the outward air, and the *action* of the fire is not great enough to break the *still*, it is by the coldness of the surrounding air (or as is commonly the case by the coldness of water placed thereon for that purpose) *condensed* and *returned* into the water contained in the body of the *still*, there to be *rarified*, *expanded*, and sent off in *steam*, as before.

We must suppose the streams of *light* to be always acting on one side of this terraqueous globe, and there *dividing*, *expanding* and *rarifying* the air; the consequence of which must be
a kind

a kind of *vacuum*, which is immediately filled by the *pressing in* of the *congealed air* from the extremities ; and as the earth is placed in this fluid of airs, we may as easily conceive that the air pressing in as above, must, with it, turn round the earth, in the same manner, and with as much ease, as water does a common mill-wheel, or the air a wind-mill. By these powers also the terraqueous globe is kept *solid* and *entire* ; for, was this *force* once taken off, it would soon drop to *atoms*, notwithstanding the pretended *attracting* power of its materials.

To confirm what is here advanced, I shall bring an experiment (which Mr. Boyle has laid down as a paradox) which proves that this terraqueous globe has no *attraction*, nor any *solid*, falling towards it, any *gravitation* ; but that all bodies *are forced* to it by the *incumbent atmosphere*, as much as water is *forced* up a pump by it (the atmosphere) which, till the time of the great Mr. Boyle, was imagined to be performed by, what they called, the *suction* of the pump. But this is no more than has often happened in philosophy, where when we cannot well account for any thing, we put the *effect for the cause*.

Mr. Boyle found that a *solid body*, as *ponderous* as any yet known, though near the top of the water it would sink by *its own weight*, yet if it be

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placed

placed at a greater depth than twenty times its own thickness, it will *not sink*, if its descent be not assisted by the *weight* of the *incumbent water*. To prove this, he gives us a curious experiment, viz. by keeping off the *pressure* of the water, from the *top* of the *sinking body*, and *sinking* it to a proper depth, he found, that the *most ponderous* body would be *buoyed up*, and *supported* by the water only. See the 2d vol. of *Boulton's epitome*, pag. 305. This experiment shews us beyond all contradiction, that the *earth* has no power of *attraction*, nor a *descending body* any power of *gravitation*; for if it had, the farther it was sunk in the water, the nearer it must be to the centre of the earth, and of consequence the *attraction* must be the greater; but this, we find, is contrary to experience; so that the whole power of descending is impressed upon it by the *air*, or by other bodies forced upon it by the *incumbent air*. This experiment alone is more than sufficient to destroy the fine theories of *attraction* and *gravitation*; it also shews us how, and by what means, two marble slabs, finely polished, are what they call *attracted* to each other, and require a great force to separate them; a force in proportion to the breadth of the slabs; but this has been shewn by other experiments to be nothing but the *pressure* of the *air*, or *atmosphere*;
for

for put them into an air pump, and extract the *gross air*, and they will immediately separate from each other.

One reason, which seems to have led us into the mistake that the *solidity*, or *firmness* of bodies is not caused by the *air*, has been, that, for the generality, we consider the *air*, or *atmosphere* as *pressing* only *downwards*; for if we had considered that it *presseth* equally *every way*, as well as *downwards*, (as *Boerhaave* in his *chym.* by *Shaw*, vol. i. p. 389. has shew by the following experiment) I believe we should not have overlooked that force, or have thought it insufficient for this operation. “Fill three glass vessels, the one of a
“cylindrical figure, the other conical, the third
“bellied with a cylindrical neck; let these be
“filled to the brim with fair water, and covered
“with a single piece of paper, so as to touch the
“surface of the water, and by pressing it down
“with the hand, prevent the external air infi-
“nuating between the paper and the water; if
“the glasses be now inverted, whilst the paper
“remains close with the palm of the hand, and
“the hand be afterwards gently withdrawn, the
“water will still remain in the glasses. The same
“holds true, though the glasses be held horizon-
“tal, or in any other position.” As the cause of
the *solidity* or *firmness* of bodies is the *pressure* of
the

the *air* or *atmosphere*, so likewise it must depend on the *make* and *size* of the *pores* of such bodies; for bodies whose *pores* are *smallest*, must be acted upon with a greater power than those whose *pores* are *largest*, or whose *pores* are so *large* as not only to admit *light*, but also *common air* into them. This Mr. *Hauksbee* proves by a curious experiment, for having placed two brass hemispheres, of $3\frac{1}{2}$ inches diameter, upon each other, and then extracting the gross air out of them by the air pump, and by these means taking off the *resistance* of the *common air* that was *within* the two brass hemispheres, he says, it required 140 pound weight to separate them; this experiment with that of the two marble slabs before mentioned, is a demonstration of the *power* that keeps *solid bodies* from *falling* to *pieces*. And even, if these slabs are not so *perfectly smooth*, yet the wetting them with water, which prevents the gross air from *entering*, will produce the like effect. That solids *expand* themselves by *heat* or *fire*, is proved by heating an iron rod in the fire: in which case, it is always found to be *bigger* and *longer* when *hot* than *cold*; and it was the opinion of *Boerhaave*, that cold *consolidates* all those that are called firm bodies; that is, brings that part, which we call *body* in them, into a *less compass* than before, and thus *unites* the matter thereof

of more closely together : by which means the *cohesion* of the whole mass is usually increased ; which makes what we call, *strength* and *firmness* in bodies.

Having shewn that *solid bodies* have no power either of *attraction* or *gravitation*, and that their *firmness* or *solidity* depends on the *pressure* of the *atmosphere* ; I shall now endeavour to shew, from electrical experiments, how, and by what means they *descend* towards the earth.

What is called the *attraction* of the *earth* seems to be performed in the same manner as that of the *glass globe* in electricity ; the explaining of which will give us a clear idea, by what means *heavy bodies* are *forced* towards the *terraqeous globe*. In accounting for this electrical *attraction*, Mr. *Hauksbee* seems to be very clear ; for, says he, “ if by the heat and rarefaction, consequent upon the attrition, the medium contiguous to the glass be made specifically lighter ; then of course, to keep up the ballance, the remoter air, which is denser, must press in towards the tube, and so carry away (in the torrent) the little bodies lying in its way, thither also. The various irregularities in the excitation, or the emission and discharge of the electrical matter or light from the tube (which will be followed with proportional irregularities,

“regularities, in the motion and tendency of the
 “denser air, towards the glass globe, by the hy-
 “drostatical laws) may be sufficient to account
 “for the various uncertain motions of the little
 “bodies carried towards the glass globe.” This
 account of Mr. *Hauksbee*’s being so very clear, it
 is a little surprising that he should allow the
 power of *attraction* to matter, as in some places
 he does; for this is no more than in other words,
 telling us, that the air round the ball is *divided*
 and *rubbed* or *ground* to pieces by the *friction* be-
 tween the glass globe and your hand, and there-
 by made to *expand* itself; so the air pressing in
 to make up that deficiency, forces every thing
 towards the glass globe, that by its number of
 particles is not able to withstand the *current* of
air, pressing towards the globe. So in like man-
 ner near the surface of the earth, the sun-beams
 being *reflected* by the terraqueous globe, must by
 these means be in a greater quantity near the sur-
 face of the earth, than at a distance from it; and
 so *divide*, *expand* and *rarify* the air near its sur-
 face, which *rarified* or *divided* air is forced off
 from the earth on all sides, by the *pressing* in of
 the air from above, which must of consequence
drive every thing before it, towards the earth.
 By which we find, that the cause of bodies *de-*
scending towards the earth, is not from any *pro-*
perty

perty either of the *earth* or of the *descending bodies*; but that these are *forced* towards that, by the *surrounding air*, in its said *motion*.

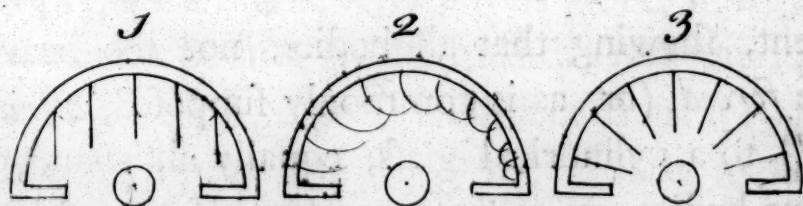
To prove that this is the method by which, in electricity, bodies are forced towards the glass globe, I shall bring an experiment or two from Mr. *Hauksbee*; and as these experiments prove to a certainty, that this is the manner of the *attraction* in *electricity*, it will give us little room to doubt, but that the *attraction* of the *earth* is performed in the same manner.

Mr. *Hauksbee* observed, that the *electrical effluvia* were not only perceivable by sight; but also, if the hand was held near the tube, seemed to make such sort of strokes upon the skin, as a number of fine limber hairs pushing against it might be supposed to do: and in order to find whether the electrical *attraction* was regular and uniform, he made the following curious experiment, shewing that all bodies, not too heavy, are *forced* (or, as is commonly supposed, *attracted*) to a cylindrical glass, equally all round, if these bodies are, as *they term it*, within the sphere of its activity.

This experiment seemed to affect Mr. *Hauksbee* so much, that (speaking of electricity) he says, "it affords us a sort of *representation* of the "*great phænomena* of the *universe*." Page 53.

"For

“ For, says he, having observed (in electrici-
 “ ty) that light bodies, placed near any part of
 “ the rubbed cylinder, seemed to be equally at-
 “ tracted, I contrived a semicircle of wire, which
 “ I could fasten at a constant distance, making it
 “ encompass the upper semi-cylindrical surface
 “ of the glass, at 4 or 5 inches distance. This
 “ wire had several pieces of woollen threads fas-
 “ tened to it at pretty near equal distances. The
 “ length of them was such, that being extended
 “ in a direction towards the center of that imagi-
 “ nary circle, on the surface of the glass, in the
 “ plane of which the wire was placed; they
 “ would then reach within an inch of the cir-
 “ cumference of that circle: but if left to their
 “ own liberty, they hung in that parallel posi-
 “ tion represented, fig. 1. The cylinder was



“ placed with its axis parallel to the horizon;
 “ and in this posture, it was turned swiftly
 “ round

“round; and then by the rapid motion and agitation of the surrounding air, the threads were placed into such positions, as are expressed fig. 2. viz. they were all lifted up and bent upwards from the axis of the cylinder.

“All this while, there was only the swift motion of the cylinder round its axis, without any attrition, but now when I came to apply my hand to the lower part of the glass (so swiftly whirled about) and consequently to add attrition to the former motion; the threads presently began to change their direction, and all harmoniously pointed to the center of the circle, in whose plane the wire was placed, as in fig. 3. neither were they at all disordered or flung out of that position, by the wind occasioned by that violent motion (but as if there had been no such hurry of air about them) they still persisted in their central direction; I found I could by shifting the place of the attrition higher or thither, draw the threads towards this or that end of the cylinder; but yet they all still went uniformly converging towards some center in the axis of it; so that they formed themselves into a sort of conical surface.

“Farther, if the wire with its loose threads was reverted, so as to encompass the lower part of the cylinder (as before it did the upper part)

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“yet

“ yet the effect still answered with the same ex-
 “ actness. For the threads were all erected into so
 “ many strait lines, still directing themselves to-
 “ wards a center in the axis of the glass.

“ Hitherto the axis of the cylinder was placed
 “ horizontally; in the next place I set it in a ver-
 “ tical position, so that it stood perpendicular to
 “ the plane of the horizon; in which case I made
 “ use of a wire hoop, which was necessary to be
 “ placed parallel to the horizon, that it might
 “ encompass the cylinder, in the same manner as
 “ the semicircular wire did before: only one
 “ small part of this wire was left open, to make
 “ way for the touch of the hand, which was to
 “ give the attrition. And the wire being thus
 “ placed, it was evident that the threads (without
 “ some external force to support them) must all
 “ sag and hang perpendicularly downwards. Yet,
 “ as soon as the motion and attrition were given,
 “ the threads presently began to be extended; and
 “ as if they were become stiff and hard, formed
 “ themselves into an horizontal plane; their loose
 “ ends pointing to a center in the axis of the
 “ glass, as before.

“ And thus (in all sorts of positions whatsoe-
 “ ver, both of the wire and of the glass too) were
 “ the threads acted upon by a sort of centripetal
 “ force; to the laws of which they were always
 “ con-

"conformable. See *Hauksbee's* experiments, page
"53 &c.

It may be observed in this experiment, that the *attractive* power of bodies does not lie in *solids*, as has been falsely imagined, neither have such bodies any *centripetal* or *centrifugal* force; but that this *power* and *force* are given them from *without*. For, on placing the wire with the threads round the cylinder, they were all *forced* (or as it is often called, *attracted*) towards the *earth*; but, on giving a *violent motion* to the cylinder, they were drove from the cylinder, as if forced by a strong wind; but, by applying the hand to the glass cylinder, they were recalled, and all pointed to a center in the axis of the cylinder: and this *central* direction might be altered at any time, by only moving the hand to different parts of the cylinder; the threads always pointing to the place where the *attrition* was made: by which we find, that the *central* force, both of the cylinder and the threads, are caused by the *attrition* of the *air* between your hand and the cylinder; whereas, at any other time, they are quite inactive: so we are assured that these *central* forces which have been imagined to be *within* the *solid*, are not there, but in the *air without it*.

On putting something between any of the threads and the cylinder; then, those threads
would

would return to their first and *natural position*, viz. point towards the center of the earth. So, as Mr. *Hauksbee* observes, “in these small orbs of matter we have some little resemblances of the *grand phænomena* of the *universe*.”

Another thing observable was, “that by putting these threads within a glass, when they became extended, this position of the threads would be altered at any time on the approach of one’s hand, finger, or any other body, to the surface of the glass.” This is sufficient proof that the *light*, or as it is generally called, the *electrical effluvia* pass through the *glass*, with as much ease as water does through a sieve.

One thing which seemed a little surprising to Mr. *Hauksbee* was, that upon exhausting the *gross air* out of the tube or globe made use of in electricity, what he called the power of *attraction*, would cease; but upon suffering the air again to enter, it returned as vigorous as before. This must be the case; for (as was before observed) whenever the gross air is extracted by an air pump, the fluid remaining is nothing but *light*. So, whenever this attrition is performed on an exhausted globe (for want of the resistance of the gross air within, to force off the particles of air ground so small as *light*, and thereby to make an *expansion* or *rarefaction* round the glass globe, which

which has been shewn to be the cause of light bodies being *forced* towards the globe) these particles of *light* do immediately enter the globe on one side, and *force* out the same quantity on the other; in the same manner as water through a sieve, without ever making any *expansion* or *rarefaction*.

Having thus shewn how and by what means the *fire* and *light* in electricity are produced; our next inquiry must be, why some bodies communicate this *light* to ever so great a distance, and that instantaneously; whilst others will not; and also, why some bodies are *electrical* and others *non-electrical*.

Electrical bodies are those, whose *pores* are so *fine*, as to admit nothing through them but *light*, or air ground to a proper fitness; as *metalls*, *glass*, *amber*, *wax* &c. Bodies *non-electrical*, are all those, which, by the *largeness* of their *pores*, admit, not only *light* but also *gross air*.

We see, when the air is *gound* to pieces by an electrical machine, and *put* into *sufficient motion*, by the *friction* between the glass globe and the hand, a wire being hung from the iron barrel, so as very near to touch the ball, part of the *light* issuing from the ball, as above described, *enters* the wire, and is by it communicated to the iron barrel, and from thence *carried* by another
wire

wire to any distance, if not interrupted by some *non-electrical* body: to the end of which, by a third wire is hung an egg; as soon as the globe is put in *motion*, and warm spirit of wine is placed so as to touch the egg, the spirit of wine will immediately take fire from the contact of the egg.

It has been already proved, that when the globe is put in *motion*, and your hand is applied to it, it *grinds* to pieces the air between the globe and the hand, and so *rarefies* and *expands* it, and sends it off with great force, in the same manner, as *light* is sent from any body of *fire in action*; as may be seen, if the electrical machine is set at work in the dark; when the emission from the glass globe will appear lucid.

The wires which are hung over the glass globe, by the *smallness* of their *pores*, admitting nothing through them but *light*, and light being a body so *subtil*, as to penetrate the *pores* of all other bodies, even to the very center of the earth; the *interstices* of the *wires* are filled with it from one end to the other.

As the *light* is one continued body, throughout the whole extent of the wire, the *force* it receives at the end next the glass globe, is *immediately*, and at the *same instant* of time, communicated to the other end, let the *length* or *extent* of the wire

wire be ever so great. As, for example, a pipe of any length, being filled with any sort of fluid, as water ; if you force in more water at one end, the same moment, and in the same quantity, it will be forced out at the other.

By these experiments in electricity, we find that *fire* and *light* are produced as has been before observed, only by *breaking* the air to pieces, and putting it in *motion* ; and that *fire* and *light* are in *all* bodies, water and ice not excepted ; for, if a piece of ice is hung at the end of the wire, it will set fire to spirit of wine, as well as an egg.

The iron wire by the *closeness* of its *pores* prevents the surrounding air from entering it, and by that means at the same time forms a kind of *canal* for the *light* to pass through.

Having thus as I conceive, given a tolerable clear account, and, I hope, a true one, how and by what means, the various *phænomena* in electricity are produced ; I suppose, it will not be a very difficult task, to form a judgment, what disorders electrical operations are likely to be applied to, with hopes of service ; as also in what others they are likely to be detrimental.

As the *heat* and *redness* of the *blood*, may be easily proved, to be in proportion to the *quantity* and *motion* of the *light* it contains ; so, wherever the blood is *beated* to a great degree, as in *fevers*,

Inflam-

Inflammations of all kinds &c. there we are to expect the worst and most pernicious consequences, from the use of electricity.

But, on the contrary, as the nerves have been proved to act by a subtil fluid that passes through them, and that they, by the closeness of their pores, will not admit a fluid to pass through them, whose particles are much larger than those of *light*; the consequences we must often expect from such a make, must be obstructions; and as the *light* in electricity is forced through our bodies and nerves, with great violence, it seems very reasonable to think, that where these obstructions are not too violent, there they may be broken through and removed by its power, of which we have had many instances, especially in palsies.

This is also confirmed by the success of the present practice of physick; for, the greatest relief, in these cases, is always found to proceed from *volatile* and *penetrating* medicines. But, care should be taken, not to administer electricity, to a person of weak and decayed nerves, instead of one whose nerves are obstructed.



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